

**National Aeronautics and Space Administration  
Washington, DC**


**NASA ADVISORY COUNCIL**

**March 30-31, 2017**

**NASA Headquarters  
Washington, DC**

**MEETING MINUTES**

  
P. Diane Rausch  
Executive Director

  
Lester L. Lyles (USAF, Ret.)  
Chair

**NASA ADVISORY COUNCIL**

**NASA Headquarters  
Washington, D.C.**

**Public Meeting Minutes  
March 30-31, 2017**

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***Meeting Report prepared by  
Joan M. Zimmermann, Ingenicomm, Inc.***

**NASA ADVISORY COUNCIL**

**NASA Headquarters  
Washington, DC**

**PUBLIC MEETING**

**March 30-31, 2017**

**Thursday, March 30, 2017**

**Call to Order, Announcements**

Ms. Diane Rausch, Executive Director of the NASA Advisory Council (NAC or Council), called the first NAC meeting of 2017 to order and welcomed Council members and attendees to the first NAC meeting of 2017. She explained that the NAC is a Federal advisory committee established under the Federal Advisory Committee Act (FACA), and as such was subject to relevant Federal regulations and laws. The meeting is open to the public. She noted that meeting minutes would be taken and posted to the NASA website, [www.nasa.gov/offices/nac](http://www.nasa.gov/offices/nac). Each NAC member had been appointed by the NASA Administrator, based on the member's individual subject matter expertise. All members are Special Government Employees (SGEs), subject to Federal ethics laws and regulations, and must recuse themselves from discussions on any topic in which there could be a potential conflict of interest. Ms. Rausch informed members, attendees, and speakers that the meeting was a public meeting, and as such, all presentations and comments will be part of the official public record.

Ms. Rausch introduced the new NAC Chair, General Lester L. Lyles, and turned the meeting over to him.

**Opening Remarks by NAC Chair**

General Lyles welcomed all meeting attendees. He said he was honored to be the new Council Chair, having been appointed by former NASA Administrator Charles Bolden, and subsequently affirmed by the Acting NASA Administrator, Mr. Robert Lightfoot. He stated that he took his Council Chair responsibilities very seriously, and looked forward to taking on a challenging and meaningful role in supporting and advising NASA. He reviewed the day's agenda briefly and led introductions by Council members around the table.

Members engaged in a brief discussion. Dr. Bradley Peterson, Chair of the NAC Science Committee, reported on the recent restructuring of the NAC Science Committee, specifically, four of its five subcommittees becoming independently chartered NASA FACA advisory committees. The latter will henceforth serve as direct advisors to the Science Mission Directorate's (SMD) Division Directors. To ensure close coordination and avoid duplication of effort, the chairs of these four new FACA advisory committees will continue to serve as members of the NAC Science Committee. The NAC Science Committee is also in the process of re-evaluating how it can better and more expeditiously serve NASA. Mr. Kenneth Bowersox, former NAC Acting Chair and now returned his former position as Chair of the Human Exploration and Operations (HEO) Committee, noted that he was pleased to learn of recent changes to NASA's deep space program, and was re-engaged with the work at the International Space Station (ISS), Commercial Crew Program, and the Space Launch System (SLS). Ms. Marion Blakey, Chair of the Aeronautics Committee, expressed her enthusiasm about NASA's direction and strategy in aeronautics. Noting that the NASA Aeronautics Research Mission Directorate (ARMD) had once been more oriented to lower Technology Readiness Level (TRL) projects, Ms. Blakey said that her committee was now quite excited about ARMD's new work in autonomous technologies, and on issues that make a difference in the lives of Americans. Dr. William Ballhaus, Chair of the Technology, Innovation and Engineering (TI&E) Committee, looked forward to the ongoing

rebuilding of NASA's technology program, which had been decimated by cuts in the past. He noted that former Administrator Charles Bolden had worked hard to re-engage human capital at the universities. Two areas the TI&E Committee planned to focus on were the appropriate role of small spacecraft in NASA endeavors, and identifying barriers to innovation at NASA. The TI&E Committee and the Office of the Chief Technologist (OCT) are in the process of responding to a report on the subject of innovation, which had been carried out by the Institute for Defense Analyses (IDA). One of the report's conclusions centered around "speed" as a key to innovation. He noted that OCT was taking on the task of breaking down some of the report's identified barriers to innovation. Dr. Kathryn Schmoll, Chair of the Institutional Committee, reported progress on its ongoing review of NASA Business Service Assessments. She reported that her committee strongly believes that NASA is ready to respond to the Executive Order of March 13, 2017 (addressing inefficiencies in the Federal government). Her committee has also spent a moderate amount of discussion time on Information Technology (IT) issues at NASA.

General Lyles introduced the NASA Acting Administrator, Mr. Robert Lightfoot.

Remarks by NASA Acting Administrator

Mr. Lightfoot welcomed General Lyles as the new Council Chair, and acknowledged General Lyles' long history serving on the NAC in various capacities. He thanked Mr. Bowersox for his recent service as Interim Council Chair, and Dr. Wayne Hale for his service as Interim Chair of the NAC HEO Committee. He welcomed the new Council members, Dr. Penina Axelrad (member at large), Dr. Alan Epstein (ex officio, representing the National Academy of Engineering's Aeronautics and Space Engineering Board), Dr. Fiona Harrison (ex officio, representing the National Academy of Science's Space Studies Board). He noted that recently the NAC science subcommittees have been re-chartered as independent committees. Their new names are: Astrophysics Advisory Committee (APAC), Earth Science Advisory Committee (ESAC), Heliophysics Advisory Committee (HPAC), Planetary Science Advisory Committee (PAC), and HEO Research Committee (HEORAC). The chairs of the former subcommittees will retain their prior positions members of the NAC Science Committee and NAC HEO Committee, respectively. Mr. Lightfoot reported having been busy with the Space Technology Mission Directorate (STMD), working with industry and academia. Thirteen university-led projects were recently selected to carry out early stage innovation grants, worth about \$500K each, and extending for a period of 2-3 years. There are also two proposals under way for oxygen recovery technologies, meant to support NASA's push into space. This latter effort represents about \$2B of expenditure over 24 months. NASA is also selecting proposals for other technologies critical to humans in deep space. Two new Space Technology Research Institutes (STRIs) have been stood up; one focused on biomanufacturing in space, known as CUBES; and the Michigan-based Institute for Ultra-Strong Composites by Computational Design, known as US-COMP. NASA is also partnering with 8 companies involved in small satellites and other small spacecraft, in an effort to advance public-private partnerships in this growing area. Overall, there are 133 proposals in the NASA Small Business Innovation Research (SBIR) for enabling future missions, about \$100M total. NASA recently released its *Spinoff 2017* publication, highlighting 50 companies that are currently making use of NASA technology.

Mr. Lightfoot was happy to report a continuing international commitment to ISS; the European Space Agency (ESA) has formally committed to support the ISS through the year 2024. NASA is appointing the astronaut crewmembers for Expeditions 55 and 56 to the ISS, including Dr. Jeanette Epps, who will be the first female African-American astronaut crew member to the ISS. NASA is also working options for Soyuz seats. In the cargo supply chain, a Dragon X capsule recently carried 5000 pounds of supplies to the ISS. The launch vehicle launched from the prior Space Shuttle launch pad 39A, and the capsule was returned on March 19, 2017. The SLS program was set back slightly by a February tornado at the Michoud Assembly Facility (MAF) near New Orleans, which caused significant damage. However, the teams are in good spirits and getting back to work. NASA Marshall Space Flight Center will be hosting 100 high school and college teams in an Exploration Rover Challenge beginning April 1, 2017. NASA Stennis Space Center recently carried out the first test of the RS-25 engine, which will function as the flight controller for the Core Stage of SLS. In February 2017, Mr. Bill Gerstenmaier, HEOMD Associate Administrator (AA), authorized a technical feasibility study for possible human crew activities on EM-1 (Exploration Mission-1) to be launched using SLS. In Earth Science, the geoCARB satellite was selected out of 15 proposals; this is a small Earth Venture mission that will study carbon dioxide, methane, and carbon monoxide



concentrations in atmospheric columns. The NASA Earth Science Division also successfully launched the Cyclone Global Navigation Satellite System (CYGNSS) mission, an interesting 8-cubesat formation that will study hurricanes, and is now in its science operations phase. The NASA Marshall Space Flight Center is participating in the development of an x-ray imaging polarimeter to study extreme and exotic astronomical objects. Two other missions for exploring the earliest Solar System have also been selected for launch in 2021 and 2023: Lucy, an excursion to study Jupiter's Trojan asteroids; and Psyche, which will explore a unique metal asteroid. The Spitzer Telescope and ground-based assets have confirmed the existence of an exoplanetary solar system of 7 planets, TRAPPIST-1. In aeronautics, efforts to develop a future, quieter, supersonic passenger airplane at the NASA Glenn Research Center were carried out using wind tunnel testing of a 9% scale model of the X-plane, simulating speeds of Mach 1.3 to 1.6. In mission support, NASA has been working on improving the efficiency of business services and institutional needs.

Mr. Lightfoot felt that the FY 2018 President's Proposed Budget for NASA, with top line numbers of a little over \$19B, is a good budget for the Agency. While NASA clearly will have to work some budget issues and reductions, it has been left relatively unscathed in the budget process. The budget will support the continued push of humans into space, commercial space endeavors, and stable funding for science. Four Earth Science missions – Plankton, Aerosol, Cloud, Ocean Ecosystem (PACE), Climate Absolute Radiance and Refractivity Observatory (CLARREO) Pathfinder, Orbiting Carbon Observatory (OCO-3), and some operations on NuStar – have been cancelled. However NASA will continue its commitment to Earth Science. The aeronautics program remains stable after a period of slow increase; the FY 2018 budget still supports the Aviation Horizon activity. The FY 2018 President's Proposed Budget for NASA includes no formal Office of Education, however, Mr. Lightfoot stated that NASA is committed to Education, whether it has an office or not. While NASA's Asteroid Redirect Mission (ARM) has been cancelled, Mr. Lightfoot wanted to publicly state that HEOMD had done a tremendous job in planning the mission, and will continue to develop ARM-associated solar electric propulsion (SEP) as an enabling technology for future NASA deep space missions. Mr. Lightfoot also noted that he had been asked to develop an alternative plan for ARM. The NASA Transition Authorization Act of 2017, signed earlier this month, affirms that the ISS will operate through 2024. The Transition Authorization Act also established an occupational health program for the lifetime of astronauts. It will support former and current astronaut crew health care, increase our longitudinal database, and will be part of the ethical framework going forward. The Transition Authorization Act enjoyed bipartisan support. He noted the retirement of Mr. Donald James from the NASA Office of Education, and his interim replacement, Mr. Mike Kincaid, from NASA Johnson Space Center. Ms. Jen Rae Wang has recently been named the AA for Office of Communications, and Mr. Robert Jacobs will be her deputy. Mr. Lightfoot noted the passing of Apollo astronaut Eugene Cernan in January 2017.

Mr. Lightfoot closed by stating that the advice of the NAC is taken very seriously by him and the NASA leadership, and that he appreciated the programmatic expertise and technical depth of the Council members. He further stated that NASA was still in a very good position to do many amazing things.

General Lyles remarked that NASA has been recognized as the "best place to work" in the Federal government for several years in a row, and asked Mr. Lightfoot to comment on how NASA and its workforce morale stays so strong. Mr. Lightfoot felt that NASA was strong due to its extremely dedicated and committed workforce, who recognized the value of its missions, as well as the habit of open communications among the members of the workforce. Ms. Blakey suggested that NASA offer workshops on this issue, and that NASA might benefit from dissecting the reasons for its success. Mr. Lightfoot noted that NASA still spends a lot of time looking at survey data, and each year tries to take a few lower-performing categories and study them for ways to improve issues such as engagement, and leaders leading. Dr. Wanda Austin wondered how NASA was doing with the other international space agencies. Mr. Lightfoot reported that NASA is always actively engaged in space diplomacy, and meeting with Agency counterparts around the world. There will be 15 or 16 countries at the next round of bilateral talks. This is exciting because there is global enthusiasm for science and space exploration, and NASA recognizes that continued success will require international partnership. NASA tries to communicate this philosophy as much as possible, and to maintain good relationships. NASA provides a lot of leadership for the global community. Dr. Elisabeth Paté-Cornell asked about NASA efforts in cybersecurity. Mr. Lightfoot acknowledged that cybersecurity is recognized as one of NASA's top risks at the enterprise level. NASA is trying to subdivide it into the regions of tactical everyday use and of protecting assets. NASA has an enterprise protection program to understand threat and mitigation. The biggest challenge is legacy systems. The Agency has a good process for risk analysis and prioritization, and is well connected

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with the other Federal agencies, using their tools when possible to avoid duplication of effort. General Lyles expressed interest in how the NAC can assist NASA in this area. Mr. Wayne Hale commented that he was interested in hypersonics and asked what is planned in research with other national agencies. Mr. Lightfoot said there is an aggressive NASA effort in materials research and flight research. NASA is seeking partners to see where workforce and facilities play roles. There is a lot of interest in hypersonics government-wide, but more on the research and system analysis side. Mr. Hale felt it should be noted that NASA has leadership in this area, in Mars entry and landing technologies, in particular. General Lyles mentioned that in the past there had been an interagency National Space Council chaired by the Vice President that met to discuss mutual interests; hypersonics would be an excellent topic for discussion if/when this body is re-established. Mr. Lightfoot agreed and stated that there might be an opportunity to stand up such a National Space Council once more.

### President's FY 2018 Proposed Budget for NASA

Mr. Andrew Hunter, Acting Chief Financial Officer, presented a budget briefing on the recently released FY 2018 President's Proposed Budget for NASA ("skinny budget"). He stated the budget was relatively good news for NASA in the present budget environment. NASA is rolling off a transition year and has undergone a two-step budget process. The proposed NASA budget for FY 2018 is \$19.1B. The budget focuses on deep space exploration, while totaling about 1% below the 2016 budget. NASA has been told to expect flat outyear funding. The Administrator will roll out its full FY 2018 President's Budget Request in May 2017. Mr. Hunter stated he does not anticipate any need to reduce the NASA workforce beyond normal attrition rates. In the context of the deep cuts experienced throughout the Federal government, Mr. Hunter felt that NASA had done quite well. The current blueprint includes \$3.7B for HEOMD, largely for SLS and Orion. In Planetary Science, \$1.9B has been allocated to include a Europa mission, but without a lander. Earth Science was allotted \$1.8B, and was directed to terminate 4 missions. Aeronautics has been allocated \$624M. The President's Budget Request for FY 2018 eliminated NASA's Office of Education, but it does not impact the education activities of SMD; internships and post-graduate fellowships remain funded in other accounts. The funding markup comparison across the legislature runs from a high of \$19.5B in the House, to \$19.3B in the Senate.

### Human Exploration and Operations Update

Mr. William Gerstenmaier, NASA AA for HEOMD, presented a briefing on human exploration activities, beginning by noting the day's spacewalk to attach a Pressurized Mating Adapter (PMA) to the outside of ISS, to replace an area of missing debris shield. He noted that Michoud's post-tornado damage was further complicated by today's intense rainstorms, and would interrupt operations at the Vehicle Assembly Building. Recovery and rescheduling activities will continue apace.

The nation's goal for space exploration is to lead an effort to expand human presence in space, and to explore space in partnership with international partners and private companies. With the advent of the new Administration, the same phases apply to NASA's strategic planning for human excursions in space. In Phase 0, HEOMD will continue to solve challenges through research and systems testing on ISS. Today's life support systems are not as independent as they need to be for a crewed excursion to Mars; NASA needs to step up its efforts in this area. Determining how much water is in the regolith on the Moon, for example, could potentially change infrastructure moving forward. HEOMD wants to do some type of demonstration of such resource utilization early on. In Phase 1, NASA will conduct missions in cis-lunar space, including the assembly of its Deep Space Gateway (DSG) and Deep Space Transport (DST). This is not a single program, but a framework that others can use. In Phase 2, NASA will complete the DST vehicle and conduct Mars verification missions. ISS is a good place to test technologies and solve in-space problems such as the development of biofilms, which arose as an unexpected issue on ISS. In Phases 3 and 4, NASA will conduct human travel to Mars.

The NASA Transition Authorization Act of 2017 has codified what HEOMD has been doing all along: expanding permanent human presence beyond low-Earth orbit (LEO), with crewed missions and continued progress. Some key objectives within the Act include the continuation of ISS, which is building on past and present activities. Mr. Gerstenmaier noted that some changes in human space exploration planning had been precipitated by the cancellation of the Asteroid Redirect Mission

(ARM). In its place, HEOMD will work toward developing a 40 to 60 day mission in the vicinity of the Moon. Exploration objectives have been baselined for Phase 0 through 2. Phase 0 has been further broken down into 17 objectives, then into requirements and functionalities.

The Phase 1 DSG will be designed to orbit at various distances around the Moon, or at Lagrangian points, and serve a variety of functions, including serving as a site for robotic operations. The DSG is planned to be crew-tended by Orion (based on 11-day visits), and will have an interim set of life support capabilities; it can be used as a staging point that is not fixed in space. The DSG will not be completely built from scratch; e.g., the electric propulsion bus will be taken from ARM, and the habitation module is similar to a module that is currently onboard ISS. Airlocks are already available. HEOMD plans to set up carbon dioxide standards and habitat atmospherics, address the problem of intracranial pressure, and meet international docking standards. NASA sees the DSG and DST as two different capabilities, whereas previously it was thought they would be roughly the same entity. The functionality of the DSG will be to support multiple partner objectives, and it could be used as a node for lunar transport. It will support (with Orion docked to it) a crew of 4 for a mission of up to 42 days. HEOMD is open to trade for compatibility for operations in low lunar orbit, and is emphasizing defining early Phase 1 missions.

NASA's Exploration Mission-1 (EM-1) is currently envisioned as an un-crewed mission, but options are currently being studied for the addition of human crew members. NASA is considering launching the Europa Clipper mission on SLS, as its use can cut transit-time by 3 years and obviate the need for gravity assist maneuvers. EM-2 is planned as the first crewed launch, and EM-4 might potentially carry a Canadian arm for robotics operations. There is an urgency to get hardware ready for EM-2. NASA is working with the private sector and with international partners on developing habitation modules, and is going to need commercial flights and SLS for logistics flights. Key parameters of Phase 1 are a series of SLS Block developments, multi-translunar injection (TLI) lunar free return excursions of 8-21 days, progressing to near rectilinear halo orbits of varying lengths, to orbits that can translate from and to other cis-lunar orbits. HEOMD is reaching out to SMD and STMD for their participation and interests. Phase 2, characterized primarily by the development of the DST, will have a volume that is sized to support a crew for extended Mars duration; it is expected to carry 41 tons, and will need to be optimized for weight. NASA has until the 2027 timeframe to deliver this transport. Phase 2 comprises missions EM-6 to 11, wherein NASA will learn how to break ties to Earth, and achieve more autonomy. The DST will be expected to make 3 flights to the vicinity of Mars, and will take advantage of SLS to launch 41 tons in one piece; this latter concept is backed by some AIAA papers. The DST will be designed to support a crew of 4 for 1000 day-class missions in space, launched on one SLS 1B cargo vehicle, with resupply and minimal outfitting to be performed in cis-lunar space. SLS Block 1B will have an 8.4m fairing. Asked by Dr. Peterson if the fairing diameter could be increased, Mr. Gerstenmaier reported that SMD thinks 8.4m is large enough for most purposes.

Overall, NASA will lead future human exploration through the maximal utilization of ISS, active promotion of LEO commercialization, and ongoing resolution of human health and performance challenges. In response to a question, Mr. Gerstenmaier indicated that HEOMD does indeed have a communication plan in place to elicit public support, adding that there are natural points where milestones can be highlighted. Ms. Blakey asked whether there had been a strong community reaction to the cancellation of ARM. Mr. Gerstenmaier felt that the impact had been mild, noting that NASA had reached out proactively to partners, including international partners, while repurposing some work and capturing key information that was learned. HEOMD is still doing solar array development and SEP, and closing out other activities in an orderly fashion. Mr. Lightfoot added that HEOMD had also worked closely with the Small Bodies Assessment Group (SBAG) and built a lot of bridges to the community; the majority of comments had centered on SEP and concern that this research be permitted to continue. Mr. Gerstenmaier felt that the ARM work had also opened up more science opportunities on the lunar surface. Mr. Lightfoot agreed, noting the progress of analytical information on gravity capture. General Lyles asked whether HEOMD had received any feedback about the DSG and DST from the international partners. Mr. Gerstenmaier indicated that a lot of work progresses continually through the ISS relationships, both with commercial and international space agencies. Recognizing that NASA is not getting any big program or budget starts, HEOMD continues to plan slowly and methodically. Mr. Hale commented on the increasing detail of deep space exploration briefings to the NAC from HEOMD over time, which is just as it should be, within the budgetary constraints. The effort is to walk the line between a resilient and compelling deep space exploration architecture. Mr. Miles O'Brien asked about NASA options for a lunar lander. Mr. Gerstenmaier replied that

there has not been much discussion in the Agency, as there are no budgetary resources for developing a lunar lander. ESA, however, is talking about sending humans on the Moon, and NASA will consult with them when needed. There is a lot of uncertainty in the budget, thus it would not be a good idea to become enamored with all-new vehicles. General Lyles applauded Mr. Gerstenmaier's efforts, and asked him to comment on the quality of the next generation's workforce. Mr. Gerstenmaier expressed great excitement about the next generation, and the possibilities for EM-1, commenting that the work he has seen thus far from the "next-line superstars" has been phenomenal.

#### **Human Exploration and Operations Committee Report**

Mr. Bowersox delivered comments on the most recent meeting of HEO Committee, which he noted had included attendance by Dr. Patricia Sanders, Chair of NASA's Aerospace Safety Advisory Panel (ASAP). Major events of note in human exploration included two cargo deliveries to ISS, a failure of a Progress delivery followed by re-flight, a lot of science activity for ISS Increment 50, and the aforementioned tornado damage at the Michoud Assembly Facility (MAF). The HEO Committee noted some key changes in HEOMD, where more detail was beginning to emerge in defining the boundaries between phases in the Journey to Mars. The DSG appears to be a natural progression from ARM, and the HEO Committee members felt it important to acknowledge the huge contribution the ARM team had made in advancing deep space transportation. The technical part the ARM team had most affected was the solar electric propulsion bus, as well as some consideration of habitation. DST is designed to provide for a route for lower-energy return to Earth, and the HEO Committee noted that ARM studies helped smooth these plans along, too. Strategic principles for sustainable exploration remain in place; i.e. fiscal realism, scientific exploration, technology pull and push, gradual build-up of capability, economic opportunity, architecture of openness and resilience, global collaboration and leadership, and continuity of human spaceflight. HEO implementation principles may vary. For instance, the crew might do a Venus fly-by on the way to Mars, as such a maneuver rests on the general principle of exploring the Solar System. International partnerships and a role for the commercial sector are also included in the concept. The DSG is an exciting concept too, as a way station, and as a risk reducer for everyone who goes to the Moon. The Commercial Crew Program has also made significant progress over the last quarter, and continues to work with ISS and commercial crew. ISS Increment 50 included 2 Americans, 3 Russians, and 1 European crew member. Together they carried out a lot of extra science work, and a number of Extra Vehicular Activities (EVAs) to replace conventional batteries with lithium ion batteries. There is a leak in one of the ammonia loops aboard ISS; a solution is still in progress as the crew tries to locate its origin. The OA-7 Cygnus spacecraft, scheduled to be launched by Atlas V vehicle, has been delayed due to an anomaly in the launch vehicle; this issue is in work. Commercial resupply contracts are being awarded, with 8 Commercial Crew Program contracts now in process, with the work evenly divided between Space X and Boeing.

LEO commercialization work is continuing, as HEOMD explores using one of the ports on ISS for commercial activity, and is evaluating various Research, Engineering, Mission and Integration Services (REMIS) responses from industry. The Center for the Advancement of Science in Space (CASIS) and the American Astronomical Society (AAS) are finalizing plans for an ISS Research and Development (R&D) conference. The HEO Committee also received a briefing from a National Academies Decadal Survey group, which recently published the decadal document, *Recapturing a Future for Space Exploration*. A Cold Atom Laboratory, a super-cold apparatus that will allow generation of a Bose-Einstein condensate, is one of the science experiments planned for launch to ISS in 2017. Deep space habitation systems are also being demonstrated on ISS, including the inflatable Bigelow Expandable Activity Module (BEAM), which is currently focused on advancing fire safety and logistics. NextSTEP Phase 1 and Phase 2 (2016-18) operations are in progress. This work includes evolving technologies for environmental monitoring in space habitats, including carbon dioxide removal, recovering oxygen from carbon dioxide, urine brine processing, and low-mass universal waste collection. The hope is that much of this work will be completed by 2022. The team is currently refining the budget with this aim in mind.

Regarding the MAF tornado damage, which has affected work on the central tank for SLS, there is no clear date yet for recovery. It will probably take a few months. This will be a hit to the EM-1 mission schedule. The HEO Committee is also discussing: communications for NASA's exploration plans; how relevant advisory groups can interact with the Commercial Crew Program (e.g., ASAP interacts with them, but the HEO Committee does not); optimal approaches for the HEO



Committee to work with NASA; systems engineering and integration for SLS, Orion, and Ground Systems; the latest details of exploration plans and decision time frames; and budgetary impact on future plans.

The HEO Committee formulated some observations, but Mr. Bowersox indicated that the committee was not ready to issue formal findings and recommendations. Largely, HEO Committee observations centered around commending NASA on the transition preparation, expressing excitement to see that HEOMD is making decisions on going forward; the new consideration of including crew on EM-1; the need to update the Journey to Mars document, perhaps through a required roadmap publication; and the existence of ISS as a critical testbed. The HEO Committee believes it is likely that the ISS will not end in 2024, and that NASA needs to think more about the optimal timing. It is likely that the ISS will run to 2028, thus it is necessary to come up with some clear transition criteria. The HEO Committee also has concerns about budget uncertainty and flexibility in the use of funds. It also believes that the DSG might be useful in servicing deep space telescopes, but is concerned that HEOMD stay focused on its main mission. Bureaucratic processes at NASA tend to be onerous, and the number and intensity of current reviews of the HEOMD program are excessive. In addition, low SLS and Orion launch rates pose future risks to the proficiency of operations. Another tornado at the MAF, for example, could adversely affect a launch window. Dr. Ballhaus commented that reviews without accountability add no value to missions and programs. Mr. Bowersox agreed. Dr. Ballhaus referenced his past experience with expendable launch vehicles, and their success in scheduling consistent and consecutive launches. He felt that the problem is that one monopoly can replace another, with the risk that reliability will be affected; it is in fact a national security risk. Mr. Gerstenmaier added that HEOMD is very concerned about this, and is spending a lot of time watching the cuts at ULA. General Lyles noted the HEO Committee's kudos to the ARM team, and thought the NAC might want to raise its visibility to make it a formal finding. Another potential formal finding is the ISS 2024 observation. Mr. Bowersox thought the HEO Committee may raise the ISS observation to a formal finding at its next meeting. Following discussion, the NAC approved the following finding for the NASA Administrator:

*The Asteroid Redirect Mission (ARM) team has worked diligently over the last several years to develop the systems and operations to retrieve a large sample from an asteroid and return it to the vicinity of the Earth. The mission analysis and system design work performed by the ARM team will have tremendous influence on the way deep space exploration will be performed in the future. The NASA Advisory Council commends the members of the ARM team for their hard work and creativity.*

#### Science Committee Report

Dr. Bradley Peterson presented the most recent activities of the Science Committee, which has been engaged in filling a number of vacancies. He began the briefing with a series of science findings. The Geostationary Operational Environmental Satellite-R (GOES-R) satellite observations of a G-2 2016 solar storm have shown that the mission is primed to support space weather predictive capabilities. Storms of such magnitude are seen about 10% of the time during a solar cycle, and can affect the communications and power grids. The NASA Radiation Dosimetry Experiment (RaD-X) showcased some dose measurements at various altitudes, revealing that the number of particles (relative to their impact on life) is optimal at 60,000 feet of altitude. Radiation damage increases as altitude increases due to increased generation of secondary particles. In Earth science, studies of the global distribution and dynamics of surface soil moisture have shown that only 10% of Earth is used for food production. In planetary science, ground assets observed a small asteroid passing within geosynchronous orbit only 6 hours after discovery; an asteroid of its size could have wiped out a city. Images from Pluto indicate that the small body undergoes reorientation and faulting on its surface, and also harbors an ocean. Its surface also demonstrated vertical motion of glaciers due to convection; this phenomenon can affect spin. A Lake Superior-sized ice deposit was discovered on Mars (Utopia Planitia), and is considered potentially useful for in-situ resource utilization (ISRU). In astrophysics, the largest batch of Earth-size habitable zone planets have been detected around an M-type single star, which, notably, are the most common stars and cannot be seen with the naked eye. This planetary solar system, named TRAPPIST-1, was discovered by transit astronomy. Three planets in the TRAPPIST system seem to be in the habitable zone; the James Webb Space Telescope (JWST) may be able to look for similar systems, seeking biosignatures with transmission spectroscopy.

Dr. Peterson noted recent changes in the Science Mission Directorate (SMD) with the advent of Dr. Thomas Zurbuchen as the new Associate Administrator. He reiterated the recent NAC restructuring in which four of the five subcommittees of the NAC Science Committee have been formally chartered as independent Federal advisory committees, and noted that these new committees would be responsible for structuring activities such as NASA Senior Reviews and Science Definition Teams. The NAC restructuring, however, has prompted an effort by the Science Committee Chair and SMD Associate Administrator to retool its approach to advisory functions. Dr. Thomas Zurbuchen was then introduced to the Council, and made some brief comments, saying he appreciated the passion and critical eye from the Science Committee. He stated that SMD is all about the impact of research, which changes what we know and how we think about the big questions, such as life elsewhere in universe, protecting Earth, weather forecasting, water management, planetary defense, and space weather. Dr. Zurbuchen said he strongly believed that ambitious science does drive innovation. General Lyles asked for thoughts on growing the next generation of scientists. Dr. Peterson noted that the Science Committee is planning some new mechanisms that speak to this question. Dr. Zurbuchen said that the most worrisome issue is that the next generation talent is in the schools right now, and the strategic focus is not getting the attention it deserves. The next generation has to be able to develop cross-cutting disciplines to support all the activities at NASA. Dr. Peterson closed by noting the Science Committee's next meeting will be held in two weeks, and that it was also planning a joint meeting with HEO Committee.

#### **Aeronautics Committee Report**

Ms. Blakey presented an update on the Aeronautics Committee, which continues to be very excited about aeronautics at NASA. Work being discussed fits well within the 6 strategic thrusts of the Committee's purview: safe, efficient growth in global operations; innovation in commercial supersonic aircraft; ultra-efficient commercial vehicles; transition to alternative propulsion and energy; real-time, system-wide safety assurance; and assured autonomy for aviation. The new administration and the transition team have been helpful and engaged. There is a lot of interest in unmanned aircraft systems (UAS) and the X-plane. Ms. Blakey also noted her Committee's positive reception toward the proposed FY 2018 budget for NASA and specifically, the Aeronautics Research Mission Directorate (ARMD) budget, which includes the Low-Boom Flight Demonstrator aircraft. The Committee believes there is a good partnership with other U.S. Government agencies and with industry. Following discussion, the NAC approved the following finding for the ARMD Associate Administrator:

*The NAC Aeronautics Committee finds that the current NASA Aeronautics research portfolio is relevant and forward leaning, much more so than the past. The Committee endorses the path that the Aeronautics Research Mission Directorate (ARMD) is taking and recognizes that it is headed in the right direction. The NASA Aeronautics portfolio has a promising future in meeting National needs, and it is vital that ARMD continue to build strong partnerships with other government agencies and industry.*

The Committee considered the ARMD integrated strategy for UAS introduction in the National Air Space (NAS), and believes that there will have to be a full integration of UAS into the larger national aircraft control system. The Committee concluded that ARMD has a good strategy for pulling together UAS integration fully into the NAS. NASA has completed an assessment of the UAS airspace access community and its needs. Full UAS integration is envisioned as allowing manned and unmanned aircraft to routinely operate through all phases of flight in the NAS, based on airspace requirements. The next era includes on-demand mobility (accessibility to the "average person"). Right now there is a \$3B market for very high-end cars, which is probably comparable to the future market for "personal aircraft" (defined as vehicles with a drive-fly mode). The integration of such personal vehicles will eventually require a traffic system that features on-demand mobility (ODM), a transportation model in which users have access to immediate and flexible air travel. This model assumes that a traveler will choose air transportation when a distance to the desired destination exceeds 500 miles, and is envisioned as accommodating vehicles containing 1-9 passengers. This industry is very focused on the capabilities of drive-fly vehicles, an area in which government cannot readily participate. The Aeronautics Committee sees the role of NASA as providing a broad architecture for a future ODM system, establishing and building stakeholder partnerships; promoting application space for NASA and external investments; and integrating aircraft, autonomous technologies, and systems. NASA is well respected and well positioned by ODM, which is moving very quickly. NASA will have to engage and keep pace. The Committee is encouraging NASA to partner with industry to learn a new way of thinking in a fast-moving technology field. NASA should

not try to duplicate industry, but focus instead on the most compelling areas that the U.S. Government needs to accomplish. NASA's partnership with Federal Aviation Administration (FAA) has evolved well for this purpose

Mr. O'Brien asked if there were anything NASA could do to help the FAA get comfortable with UAS, as it seems that the U.S. is losing its edge in the UAS area. Ms. Blakey acknowledged that it is a useful area for collaboration, and that it is important that NASA keep up. She further noted that claims are being made by manufacturers outside the U.S. that should be taken with a "grain of salt." Mr. O'Brien commented that on-demand aviation capability dates back to the 1920s, and that it comprises two difficult themes. One is basically autonomous flight within a system, but coupled with reliable, affordable propulsion. Additional propulsion is what is currently missing. The challenge is how to certify it. This affects engineering, and issues such as determining requirements for flying over big cities, and penalties for operating personal aircraft while intoxicated. These are necessary questions. Mr. O'Brien said he believed the FAA has recognized these issues, but that there is still no established path to safety. He also stated his belief that NASA functions as the brain trust for the FAA, and could take up some of these issues in NASA research. FAA is the strongest regulatory agency in the world, arguably. General Lyles commented that companies like Amazon are thinking about these problems, though not necessarily solving them. He stated that the NAC could include safety and certification as part of a potential observation, as well as collaboration with not only the FAA, but other agencies such as the Department of Defense (DOD). He related that Lincoln Laboratories is testing autonomous swarms of 100 unmanned aerial vehicles (UAVs), dropped from aircraft, just as one example. General Lyles commented that a strong frustration at Lincoln Laboratories is that it is a Federally Funded Research and Development Corporation (FFRDC), which sometimes hinders dialogue with the U.S. Government. Following discussion and subsequent discussion the next day, the NAC approved the following finding for the ARMD Associate Administrator:

*The NAC Aeronautics Committee is encouraged by the Aeronautics Research Mission Directorate (ARMD) investigation into concepts and technology for On-Demand Mobility (ODM). Although this field is in the early stage of development, the Committee recognizes and agrees with the high potential of this emerging market. The Committee recognizes that there is a fundamental question that needs to be answered regarding the roles of government vs. industry. NASA should not try to duplicate anything that industry is doing but focus on the most compelling areas that need to get accomplished by the government. The market is going to drive development of air vehicles but new infrastructure, certification and operational concepts, particularly in light of developments in artificial intelligence and autonomy, will be needed for the industry to flourish. In order for the U.S. to stay competitive and lead in this technology, the Committee believes that NASA needs to focus future work on these other areas in order to help the industry and the public. The Committee encourages NASA to partner with industry to learn a new way of thinking in a fast moving technology field. At the same time, NASA should maintain focus on infrastructure and certification, specifically as it pertains to autonomous systems and operational concepts.*

Ms. Blakey then offered the Aeronautics Committee's views on NASA's Advanced Composites Project (ACP), whose goal is to reduce product development and certification timelines of composite materials by up to 30%. NASA will be working on this project over the next five years. ACP has three technical challenges: effective non-destructive evaluation (NDE) processes; accurate strength and life prediction; and efficient manufacturing process development. The Aeronautics Committee believes this is a productive area for NASA, aided by collaboration between the Agency, academia, FAA, and industry. The Committee believes that NASA has been successful in developing the Advance Composites Consortium. In Fall 2016, the ACP completed a project manager's assessment, and found that ACP has a tremendous team with a sufficient amount of resources, and was well positioned for Phase 2. General Lyles asked if there were a collaboration with DOD, as the Air Force Research Laboratory (AFRL) has a strong materials directorate; it might be possible for NASA to leverage its talents and resources. Ms. Blakey noted that the Aeronautics Committee does not have a lot of defense expertise, and that she would raise the questions with the committee. Dr. Ballhaus commented that materials certification is key, and that the manufacturing process must be well understood in order to reduce the uncertainty. Structural failures of composites can be catastrophic. Dr. Epstein referenced this project and experience with the Aeronautics Roundtable, and opined that ACP is supposed to be researchers, manufacturers, and engineers working on how to certify composites as quickly as possible. It is an experiment, and as such, NASA will need to see how it goes. He stated that NASA made a good decision in standing up the ACP.



Ms. Blakey concluded with a brief description of the 2017 Work Plan for the Aeronautics Committee, which includes the ARMD FY 2018 budget assessment, New Aviation Horizons planning and management status, the Low-Boom Flight Demonstrator, and Airspace Technology Demonstrator.

**Institutional Committee Report**

Dr. Schmoll gave a briefing on the most recent activities of the Institutional Committee (IC), which has just refilled its Information Technology role with two new members: Mr. Tony Cole (FireEye) and Mr. Malcolm Jackson (consultant, formerly of the Environmental Protection Agency). The Committee is spending a lot of time on the NASA Business Services Assessment (BSA) and Facilities Implementation Plan, and met with the NASA Chief Information Officer (CIO). Other discussions have included grants, which are always on the NASA Inspector General's (IG) watch list. The Committee has decided to task three of its members with developing best practices from a customer's point of view, to shed light on potential improvements to be made in this area. The Committee also met with the NASA IG, Mr. Paul Martin, to discuss several items dating from Fall 2016. The meeting was very productive and frank. Regarding the state of BSA activities, IT, procurement, and human capital are now in the Implementation Phase. Ongoing deep-dives include technical authority, which kicked-off in February 2017. Upcoming assessments are in the areas of physical security, logistics, and chief counsel. Ms. Schmoll noted some significant inroads having been made as a result of the BSA, one example being a \$7M savings achieved by simply moving to a common collaboration tool. Progress also is being made in reducing the time of Source Evaluation Boards (SEBs), which can take two-three years in some cases. Continued progress in streamlining SEBs will require a major effort across the Agency, in order to result in better selections more quickly. Dr. Ballhaus commented that sometimes SEBs take so long in order for (bidding companies) to devise ways to combat protests. Dr. Schmoll felt that the solution may require mentoring, and to identify and task people to function as professional SEB members. In facilities management, the Institutional Committee has found that many NASA buildings are not being used, and may look to DOD to consult on demolition management. Asbestos is a ubiquitous issue for facilities. Regarding budget management scope for BSA, the Committee feels there are benefits and opportunity costs to being a U.S. Government leader. The government budget process includes workforce planning, strategic planning, etc., and never truly ends. BSA wants to look at the process, and make the budget process more of a planning budget. The NASA Centers have their own shadow systems for doing budgeting, and administrative positions have increased as a result. The NASA decentralized structure is effective but not particularly efficient, thus BSA is looking at how NASA can reduce the number of people required to "feed the system."

The NASA CIO "journey" has reached a satisfactory conclusion. Dr. Schmoll was happy to report that activities at both the Agency level and the OCIO level have been coordinated, and that NASA Center CIOs now report to the Agency CIO. The Mission Directorates now link to the Agency CIO, and as a result enjoy better communication and learning opportunities. Total IT spending across the Agency is better understood, and NASA finally has a senior person advising on cybersecurity, as well as a \$30M increase for CIO cybersecurity efforts. Dr. Schmoll submitted a revised finding to the NAC, regarding the implementation plan for centralization of staffing and classification operations. Following discussion, the NAC approved the following finding for the MSD Associate Administrator:

*After conducting an independent assessment of the NASA Human Capital Business Services Assessment (BSA) Implementation Plan and the specific business case regarding the classification and staffing functions, the NAC Institutional Committee believes the NASA decision to centralize classification and staffing functions at the NASA Shared Services Center (NSSC) is based on sound governance, good business acumen and comprehensive consideration of mission requirements and risks. The NAC Institutional Committee believes the NASA plan is a necessary and positive step for the future of the Agency, and that NASA should continue to implement the noted plans to centralize classification and staffing at the NSSC.*

Ms. Schmoll noted in closing that NASA Acting Administrator Robert Lightfoot, as well as the NASA Center Directors, are extremely supportive of the BSA.

## NASA Advisory Council Meeting, March 30-31, 2017

General Lyles asked the Council members for any additional thoughts on cybersecurity, and/or the NASA organization in general. Mr. Hale stated his appreciation for Ms. Schmoll's challenging portfolio, and addressed some of the reasons that NASA is rated so highly as the "best place to work in the U.S. Government" year after year. He enumerated some of the risks of past "historic and heroic" space exploration, and noted that the space explorers in the future will face similarly daunting risks. The NAC should keep these risks in mind when dispensing its advice to NASA.

### March 31, 2017

#### Opening Remarks by NAC Chair

General Lyles opened the day's meeting. Ms. Rausch called members to order and made administrative announcements, and returned the meeting to General Lyles. General Lyles reviewed the agenda, and made brief remarks on the day's tasks. He asked for members to reflect on the structure of the NAC itself and how the meetings are conducted, recognizing that this may be a challenge, and a new, incoming Administrator may decide to change things completely. General Lyles also wanted to pursue deeper discussions on cybersecurity, as it is a critical topic for everyone. He proposed holding a focused discussion on NASA IT issues at the NAC's next meeting, after which NAC can properly reflect on the knowledge gained. He also referred to some recent, useful, unclassified Defense Science Board reports, as well some pertinent reports from the National Academies. He noted that Dr. Wanda Austin led a major study on space resiliency, a study mandated by the White House, and which is the subject of an unclassified report that is due in April 2017. He suggested these materials as background reading for all members, in preparation for the next meeting. Dr. Paté-Cornell commented that the NAC might consider the IT structure of NASA itself in terms of statistical analysis of past events, and the analysis of vulnerability points. Mr. Hale knew that NASA was already working the topic very hard, and wondered how much NAC can or should influence the ongoing process. Perhaps the NAC should limit its focus to how NASA is doing with respect other Federal agencies? Mr. Bowersox said the NASA Aerospace Safety Advisory Panel (ASAP) had held a closed-door session on cybersecurity, and perhaps the NAC might consider a similar approach. Dr. Pat Sanders noted that the ASAP has several Panel members with the right security clearances to get this type of information, and that the issues are really cultural, structural, and clearance-related. She felt, nevertheless, that the NAC could appropriately comment on NASA cybersecurity. Dr. Ballhaus agreed that it was important to understand the characterization of threat, as the NASA Centers typically vary in the types of facilities and vulnerability they face. General Lyles stated that it was not necessary for the NAC to "get into the weeds." Dr. Epstein felt the NAC could add value less on the protection of NASA enterprise, but more on security aspects peculiar to NASA, such as spacecraft and aeronautics. General Lyles felt that the NAC could comment usefully on facilities, and ensure there is someone cleared in the program who can speak to vulnerabilities. On a different topic of NAC communications, Mr. O'Brien suggested that the NAC stream its meetings and/or engage on Twitter, to better communicate with the public. Mr. Bowersox suggested that the NAC, along with the other committees, could consider having a meeting that is specifically structured to reach out for public input. General Lyles stated that these were outstanding ideas for consideration, assuming that they could be accomplished under the FACA legal rules.

#### Public Input

No public comments were received.

#### NASA Special Presentation: "Hidden Figures/Modern Figures"

Mr. Robert Jacobs, Deputy Associate Administrator for the Office of Communications, NASA Headquarters, presented the story of NASA's engagement with the making of the film, *Hidden Figures*. In order to participate, NASA initiated a Space Act Agreement with 20<sup>th</sup> Century Fox to support the commercial film, as the Agency felt a great responsibility in ensuring historical accuracy, and he noted that this process involved many uncomfortable aspects in confronting the prejudices of the 1960s. NASA worked closely with the film director and NASA Historian, and provided imagery and other supporting materials. The renowned photojournalist, Ms. Annie Liebovitz, was commissioned to photograph the retired NASA

mathematician, Ms. Katherine Johnson, one of the subjects of the film. NASA Administrator Bolden authored an article about Ms. Johnson as well, which was subsequently published and featured with Ms. Johnson's photograph in *Vanity Fair* magazine. NASA leveraged the film experience and created a web series, entitled "From Hidden Figures to Modern Figures," which features the female African-American engineers of NASA. Mr. Jacobs related that NASA actually did the first story about its "human computers" in 2004; it just did not inspire the attention that the book did. "Modern Figures" on the NASA website has had 1 million total page views, with 80% of this traffic driven by Google searches, and about 10% by direct traffic. This is good information for NASA, which will now have to figure out where the content rests, and how to drive viewers to it. He noted that while viewers stay on [www.nasa.gov](http://www.nasa.gov) pages for about 1 minute, viewers remain on the "Modern Figures" site for 3-4 minutes. Asked if NASA is using artificial intelligence methods to drive viewers to the site, Mr. Jacobs said NASA is still trying to figure it out. There are a lot of page content duplications, and NASA is trying to tackle this too, and focus on what might work. Building on the successes of such novelties as *Sharknado*, NASA discovered the value of "second-screen events," which hit a peak for NASA with the release of the film, *Gravity*. A "second-screen" event refers to the phenomenon of multimodal viewing; i.e. watching television while checking Wikipedia on a cell phone or laptop. The same thing applied during the Oscars broadcast, with viewers hitting the NASA website while viewing the award presentation. NASA has produced about 18-19 videos for its "Modern Figures" website, which has logged 242,000 engagements on social media, with a potential reach to 682 million viewers. Mr. Jacobs described other NASA Communications activities, such as special events to mark the 100<sup>th</sup> anniversary of the NASA Langley Research Center, NASA's integration into the world premiere of *Hidden Figures* in New York City, a Martin Luther King Public Library event highlighting STEM education, and the creation of a STEM workbook for teachers. NASA recently donated the Annie Liebovitz portrait of Katherine Johnson to the National Museum of African American History and Culture, marking the event with the attendance of students and film stars. NASA Headquarters also presented an Exceptional Public Achievement Medal to Margot Lee Shetterly, the author of the book *Hidden Figures*, as well as Andy Weir, author of the book, *The Martian*.

The box office total for the film *Hidden Figures* had reached \$216M by March 2017. The film was nominated for three Oscars. Industry and peers recognize the importance of the film. Modern film writers are telling a more realistic story, which involves depictions of real problem-solving and finding a good sweet spot between reality and fantasy. General Lyles said he hoped NASA would be more engaged in supporting films and documentaries. Mr. Jacobs noted that NASA already supports 80-100 documentaries per year, plus 3 or 4 entertainment films. It is not possible to devote much more time, but the Agency is taking advantage of contacts with studios, being more creative, and consequently has been able to turn the spotlight on NASA when it is feasible. General Lyles commented that Communications and Education are intertwined, and as the Education program gets stressed at NASA, Communications can play a more pivotal role in supplementing Education. Mr. Jacobs said he looked at Education as another audience, and that Communications at NASA now means engagement, a two-way conversation. Dr. Axelrad thought the both the movie *Hidden Figures* and associated NASA events were excellent. She asked whether, internally at NASA, the "Modern Figures" program is attacking the problem of inclusion of women and minorities. Mr. Jacobs felt that this was the case, citing the close involvement of former NASA Chief Scientist Ellen Stofan and former Deputy Administrator Dava Newman in this topic. Secretary of Education Betsy DeVos and Ivanka Trump were also involved in a high-profile manner. Mr. O'Brien lauded NASA's great work, and noted that NASA Office of Communications constitutes the "Department of the Right Brain" at NASA. It is very important for NASA to understand that "widgets don't get clicks; it's about the human struggle." NASA can create its own agenda by holding more public events such as these. Mr. O'Brien was curious, however, about what opportunities NASA has turned down. Mr. Jacobs explained that while NASA could do more with more resources, of course, the Agency chooses to support "feasible fiction," and pursues conversations with film producers about inaccuracies and the like. NASA did not support the movie *Life*, for instance, which was basically a horror film taking place in space. NASA generally gets involved with helping films "stink less." Mr. O'Brien asked what NAC could do to reinforce the importance of Communications. Mr. Jacobs asked that the NAC simply reinforce the value of public engagement. He cited past difficulties in trying to highlight the test flight of Exploration Flight Test-1 (EFT-1) as an example. The Office of Communications had sought get imagery of the apex of the EFT-1 flight, and capture its splashdown. However, because imaging was not a technical requirement for the flight, the public engagement opportunity was missed. Mr. Hale personally thought that the visual images are extremely important, but that this view was not always shared by Program Managers because such optics do not directly support the mission. He felt it important to "show" the story with high-quality imagery. Mr. Jacobs noted that NASA has added public engagement to the NASA Policy Requirement (NPR) 7120.5 revision; the question is whether the codified requirement has teeth. Dr. Peterson

agreed that visuals are very important. He stated that the Apollo program had essentially lost its audience by Apollo-14 due to lack of imagery. It also would have been great to be able to launch cubesats along with the James Webb Space Telescope (JWST) to image and capture the moment it unfolds in space. Mr. Hale felt such direction has to come from the top. General Lyles thought this subject could be the source of a useful NAC recommendation. Ms. Blakey stated that it would also be helpful if the NAC could do more to reinforce the follow-up on its recommendations.

**Technology, Innovation and Engineering Committee Report**

Dr. Ballhaus presented the latest activities of the Technology, Innovation and Engineering (TI&E) Committee, first reiterating the committee scope: all NASA programs focused on technology and innovation across the enterprise. He then presented a series of observations from the TI&E Committee's July 2016 and November 2016 meetings: NASA needs cutting edge technology to undertake its missions, and is still recovering from drastic technology budget cuts during the 2005-2009 timeframe. In order to reverse this decline, NASA established the Office of the Chief Technologist (OCT) in 2010 and the Space Technology Mission Directorate (STMD) in 2013. NASA has made progress in rebuilding the cross-cutting technology program as well as in making focused investments in technology development in HEOMD and SMD. The TI&E Committee observed that NASA management has done an excellent job in re-formulating the technology program as well as re-engaging the academic community in engineering research and technology. In addition, the NASA Transition Authorization Act of 2017 has identified a technology element quite specifically.

Reviewing agenda items from the TI&E Committee's March 2017 meeting, Dr. Ballhaus highlighted the Space Technology Research Institutes awards for 2017, and in particular two awards; the previously mentioned CUBES, led at the University of California, Berkeley, and the US COMP for advanced materials. The institutes have defined outcomes, also relevant to STMD, and committed outcomes with identified stakeholders, along with viable teams and a viable plan to achieve expected outcomes. In the area of Entry, Descent and Landing, the TI&E Committee members also heard a briefing on Entry Technologies considered for Human Mars Missions, which included inflatables, deployables, capsule concepts, and supersonic retropropulsion. The members also heard about the Revised STMD Strategic Framework, which involved reframing and repackaging the strategy with a focus on challenges and outcomes, quantifiable measures, capabilities, and working with transition partners to infuse technologies into a particular project.

The TI&E Committee has been concerned about barriers to innovation at NASA, and received a briefing from OCT on the subject. One identified barrier is that technologists, the agents of innovation, are spending too much time writing proposals. In the past, NASA Program Managers had used discretionary resources to fund good ideas. Today, there is too much sand in the gears. Full-cost accounting has had a deleterious effect on the speed of innovation. Intellectual leadership has been taken out of the NASA Centers. In order to speed innovation, the TI&E Committee believes that local authorities must be given the freedom to fund innovation. Discretionary resources are very limited. As noted in *Hidden Figures*, Dr. Ballhaus noted that the NASA Langley Research Center leaders made an enormous difference in the early days of the U.S. space program, and that by contrast, today there are few academicians in NASA Center management. Twenty-five years ago, there was no question about who was accountable at NASA, or who were the intellectual leaders at NASA. The other issue is the facility base. The OCT has agreed to work the issue of barriers to innovation, mapping them across the agency.

Dr. Ballhaus reviewed the results of NASA innovation surveys, which have consistently identified the barriers to innovation as: risk-averse culture, short-term focus, instability, lack of opportunity, process overload, communication challenges, and organizational inertia. General Lyles said he had just finished a similar study for the U.S. Air Force, where the three top issues identified were similar to the NASA survey results. Mr. Hale asked: what is real risk aversion? He noted that an innovation budget tends to get "beaten up by the bean-counters," who do not recognize that innovation does not come for free. There is a natural tension between the Program Manager and the Center Director. He added that a few large projects tend to provide healthy funding to a large institution. Mr. Hale said he did not know how many non-ISS projects the ISS is actually funding, but suspected that there are technology projects that do reap the benefit of the larger program. General Lyles related a Big Safari program anecdote that highlighted the perils of risk-averseness in a program that is meant to be risky, emphasizing the success of a high-risk experiment he undertook to launch Hellfire missiles from UAVs. The low-cost



experiment was successfully concluded just before September 11, 2001, after which UAVs have been used regularly to launch missiles.

Dr. Ballhaus described an overall project goal for an Institute for Defense Analysis (IDA) study of STMD, understood as determining the discriminating role of STMD. STMD's small satellite (smallsat) programs support upstream activities, while private funding for smallsats exceeds government funding, perhaps by an order of magnitude. Recognizing this state of affairs, the TI&E Committee has formulated a recommendation for the STMD AA, stating that STMD must retain its unique value in the ecosystem. In addition, the TI&E Committee felt that STMD could achieve better communications through the development of a mission statement and a transparent framework.

Dr. Ballhaus concluded with some space technology highlights in FY 2017, and additional milestones. He noted that Flight Opportunities has added Blue Origins as new flight provider, and that NASA's Small Business Innovative Research (SBIR) program will be holding a second Industry Day in June. The STMD project, entitled Adaptable, Deployable Entry Placement Technology (ADEPT), will have a pre-ship review in June 2017, as well.

#### Ad Hoc Task Force on STEM Education Report

Dr. Anita Krishnamurthi, Chair of the Ad Hoc Task Force on STEM Education, presented her report, including observations and findings from the group. The Task Force membership encompassed a range of interests and experience, including NASA experience. Dr. Krishnamurthi herself once held a position as Program Manager for Education at SMD. The Task Force last met just before NASA's FY 2018 budget had been announced, and decided to proceed with its first recommendation unchanged from the version proposed at the March 2017 NAC meeting; i.e. the budget should be aligned with the goals articulated in the NASA Education Implementation Plan (NEIP). Because budget stability is critical to long-range planning by NASA and grantees, and budgets across funding offices should be aligned with the NEIP and coordinated with the Office of Education, the Task Force felt strongly that the consequences of no action on this recommendation would be that there would be a gap between stakeholders and NASA. Education is the other side of Public Outreach, and the feeling is that NASA must continue its role in Education, at whatever level it is funded. Following discussion, the NAC approved the following recommendation for the NASA Administrator:

*The budget for NASA's education efforts should be aligned with the goals articulated in the NASA Education Implementation Plan (NEIP). Budget stability is critical to long range planning by NASA and grantees. Budgets across funding offices should be aligned with the NEIP and coordinated with the Office of Education.*

Dr. Krishnamurthi noted that the NASA Office of Education has effectively lost \$120M this year. Mr. O'Brien asked what precisely was NASA losing by losing the Office of Education. Dr. Krishnamurthi answered that the losses were the Space Grant, the Minority Research and Education project, and about \$25M in grants for the community. In addition, she noted there is no longer the 1% Education "tax" on NASA missions for Education, and that furthermore, budget turmoil adversely affects the community. The Office of Education also determines Agency priorities to which missions can contribute. Mr. Jim Stofan, a member of the Task Force, commented that the Office of Education also coordinates Education offices at all the NASA Centers, and acts as the data repository and data collector for Education metrics.

The Task Force's second recommendation is that NASA should determine a strategic focus for each solicitation cycle and prioritize the majority of non-directed discretionary funds of the total NASA Education Budget to support that strategy. Mr. Hale commented that it is hard to quantify the impact of lesson plans in the sixth grade; how do you respond to questions about this? Dr. Krishnamurthi noted that there is much research in STEM education that looks at the importance of engagement, and retaining interest in STEM past middle school, outcomes that are seen as a result of specific programs. There are also well-validated tools in place. Data collection is onerous, however, and not all programs have the funds to collect the data. The Office of Management and Budget (OMB) is very much accepting of this data. It is a process. Mr. Hale noted that STEM numbers are going down despite 50 years of effort. Dr. Krishnamurthi did not mean imply that the problem

is NASA's to solve. The Task Force feels that NASA must only clarify its role and responsibility. Cultural and social issues interfere, and that is an unfair question to pose to NASA. General Lyles asked how one might determine the impact specifically in terms of NASA funding or in terms of other influences. He added that the recommendation might be better to limited to NASA defining its role in Education. Mr. Stofan added that there are some quantifiable metrics for the graduate programs. He noted that African Americans and Latinos, and females by the 4<sup>th</sup> grade, are already opting out of STEM paths. A lot of those moments are critical, but it is just not possible to quantify them.

General Lyles wholeheartedly agreed that the problem is murky, having just ended 9 years of sitting on the Wolf Trap's Board of Directors and becoming very familiar with its "STEM Arts" program; it also had a hard time quantifying impacts. Dr. Krishnamurthi reiterated that there are tools, but that NASA also must challenge OMB on some of the questions they are asking. "Soft skills" are recognized increasingly in the business community. She was confident that it would be a fight worth pursuing to get some of these "soft skills" recognized and legitimized, and that some educational programs do in fact track the effects of engagement and subsequent improvements in grades. Following NAC discussion, the second recommendation was approved and directed to the Office of Education Associate Administrator:

*NASA should determine a strategic focus for each solicitation cycle and prioritize the majority of non-directed discretionary funds of the total NASA Education Budget to support that strategy. For example, we encourage NASA to consider focusing on particular age bands, geographic areas, segments of the population, or content areas in each solicitation cycle. To make this determination, NASA should collect and utilize additional impact data to inform solicitations and strategic directions for NASA's education programs.*

Finally, the Task Force recommended that NASA Education programs must contribute to the larger knowledge base of best practices in STEM Education. NASA Education is often mysterious to the larger Education community, thus NASA could use more external allies, especially in times of budget austerity. Grantees should publish their final reports and share their findings widely beyond traditional NASA audiences. Following NAC discussion, the third recommendation was approved and directed to the Office of Education Associate Administrator:

*NASA education programs must contribute to the larger knowledge base of best practices in STEM Education. All grantees should be encouraged to publish their final reports and share their findings widely in public presentations beyond NASA audiences. Create a public database or participate in an existing one such as the Center for Advancement of Informal Science Education (CAISE) [www.informalscience.org](http://www.informalscience.org) website to share NASA education programs' results and findings with the larger STEM education community.*

General Lyles noted that the NAC members are all passionate about the subject of STEM education, and greatly appreciated the STEM Task Force's efforts.

#### **Council Discussion and Final Wrap-Up**

The NAC members discussed tentative dates and locations for future meetings. The next NAC meeting will take place during the last week of July (July 24-28, 2017) at NASA Langley Research Center in Hampton, VA. This meeting will be the annual "all-hands" meeting of the NAC Council and Committee members together at the same venue. The following NAC meeting will take place in early December (December 6-7, 2017) at NASA Ames Research Center in Mountain View, CA. General Lyles asked members to send their thoughts on changing aspects of the NAC proceedings to Ms. Rausch, and supported Ms. Blakey's suggestion to obtain better follow-up on NAC recommendations.

In closing, the NAC members offered some final observations. Dr. Axelrad said she would appreciate more information on cybersecurity, as well as on NASA's specific roles in Education. Dr. Paté-Cornell was very interested in the cybersecurity aspects specific to NASA. Mr. Hale expressed concern about the challenges of the transition period, and felt the NAC must

pay close attention and continue to advocate for important issues. Dr. Harrison echoed a similar sentiment about governmental flux. Dr. Epstein said he was struck by the peculiar situation NASA is in. NASA excels at planning and execution of long-term missions, and is now being pressured to move much faster, and to basically ignore its traditional planning and execution roles. How will NASA adapt to On-Demand Mobility with commercial drone technology outpacing the government? Cybersecurity is another fast-moving area. Dr. Epstein felt that history indicated that NASA will be able to step up to the challenge. General Lyles was also unsure as to how NASA could adapt to operating like a business. Mr. O'Brien wondered whether the NAC should comment on the Education budget. General Lyles felt the NAC should wait and specifically address the matter at its next meeting in July 2017. His only concern that was that it might be too late, and he undertook an action to discuss this with Mr. Lightfoot. Dr. Harrison supported getting more clarity on what would be helpful from Mr. Lightfoot, and remarked that she had been part of the "1% era" for Education in SMD, and had not found it effective. She felt that the NAC should refrain from commenting on dollars or the existence of an Office of Education. Dr. Sanders agreed. Mr. Hale emphasized NASA's special role in STEM education.

General Lyles said he appreciated Mr. O'Brien's comments on 21<sup>st</sup> century public engagement techniques. Dr. Sanders welcomed the NAC's perspective, which she found valuable to the ASAP. Dr. Schmoll felt that the meeting had been productive, and that it was good to be keeping eye on Education at a time when the NAC has momentum. Dr. Ballhaus acknowledged excellent management at NASA Headquarters, with respect to Mr. Lightfoot's efforts on a day-to-day basis, to HEOMD's Bill Gerstenmaier, who has had to contend with disruptive budget swings, and to STMD's Steve Jurczyk. Dr. Schmoll issued similar praise for BSA management practices under MSD's Krista Paquin. Ms. Blakey seconded the message for ARMD's Jaiwon Shin, and expressed additional concern for the Education issue. Mr. Bowersox asked that General Lyles provide some guidance on the NAC scope and direction once a new Administrator is in place. Dr. Peterson concurred with the NAC's sentiments, and expressed particular frustration at a time in which NASA had been starting to get Education right. The other issue was continuity, and he felt that NAC should carry forth with its efforts to advise NASA until told otherwise. Ms. Rausch expressed her appreciation to the NAC members for their participation in the meeting, and invited suggestions on improving the NAC proceedings or logistics.

General Lyles adjourned the meeting at 12:00 pm.



**APPENDIX A**

**AGENDA**



**NASA ADVISORY COUNCIL**

**NASA Headquarters**

**Program Review Center (9H40)  
300 E Street SW  
Washington, DC 20546**

**PUBLIC MEETING**

**March 30-31, 2017**

**Thursday, March 30, 2017**

1:00 – 1:05 pm	Call to Order, Announcements	Ms. Diane Rausch Executive Director NASA Advisory Council
1:05 – 1:30 pm	Opening Remarks by NAC Chair	General Lester Lyles Chair, NASA Advisory Council
1:30 – 2:15 pm	Remarks by NASA Acting Administrator	Mr. Robert Lightfoot NASA Administrator (Acting)
2:15 – 2:45 pm	President's FY 2018 Proposed Budget for NASA	Mr. Andrew Hunter Chief Financial Officer (Acting)
2:45 – 3:15 pm	Human Exploration and Operations Update	Mr. William Gerstenmaier Associate Administrator Human Exploration and Operations Mission Directorate
3:15 – 3:45 pm	Human Exploration and Operations Committee Report	Mr. Kenneth Bowersox Chair, Human Exploration and Operations Committee
3:45 – 4:15 pm	Science Committee Report	Dr. Bradley Peterson Chair, Science Committee
4:15 – 4:45 pm	Aeronautics Committee Report	Ms. Marion Blakey Chair, Institutional Committee

*NASA Advisory Council, March 30-31, 2017*

4:45 – 5:15 pm	Institutional Committee Report	Ms. Kathryn Schmoll Chair, Institutional Committee
5:15 – 5:30 pm	Council Discussion	All
5:30 pm	Adjourn	

**Friday, March 31, 2017**

9:00 – 9:02 am	Call to Order, Announcements	Ms. Diane Rausch Executive Director NASA Advisory Council
9:02 – 9:15 am	Opening Remarks by NAC Chair	General Lester Lyles Chair, NASA Advisory Council
9:15 – 9:25 am	Public Input	
9:25 – 10:00 am	NASA Special Presentation: “Hidden Figures / Modern Figures”	Mr. Robert Jacobs Deputy Associate Administrator Office of Communications
10:00 – 10:30 am	Technology, Innovation and Engineering Committee Report	Dr. William Ballhaus Chair, Technology, Innovation and Engineering Committee
10:30 – 11:00 am	Ad Hoc Task Force on STEM Education Report	Dr. Anita Krishnamurthi Chair, Ad Hoc Task Force on STEM Education
11:00 am – 12:00 noon	Council Discussion and Final Wrap-Up	All
12:00 noon	Adjourn	

**APPENDIX B**  
**COUNCIL MEMBERSHIP**

**NASA ADVISORY COUNCIL**

**Membership Roster – March 2017**

<b>Position</b>	<b>Council Members</b>
<b>NASA Advisory Council</b>	<b>General Lester Lyles, USAF (Ret.)</b>
<b>Chair – Aeronautics Committee</b>	<b>The Honorable Marion C. Blakey, President and CEO, Rolls Royce North America; Former Administrator, Federal Aviation Administration (FAA)</b>
<b>Human Exploration and Operations Committee</b>	<b>Mr. Kenneth Bowersox, U.S. Naval Aviator (Ret.); Former NASA Astronaut</b>
<b>Chair – Institutional Committee</b>	<b>Ms. Kathryn Schmoll, Vice President, Finance and Administration (Ret.), University Corporation for Atmospheric Research</b>
<b>Chair – Science Committee</b>	<b>Dr. Bradley Peterson, Professor Emeritus, Former Chair, Department of Astronomy, Ohio State University</b>
<b>Chair – Technology, Innovation and Engineering Committee</b>	<b>Dr. William F. Ballhaus, Jr., President and CEO (Ret.), The Aerospace Corporation; Former Director, NASA Ames Research Center</b>
<b>Member at Large</b>	<b>Dr. Wanda M. Austin, President and CEO (Ret.), The Aerospace Corporation</b>
<b>Member at Large</b>	<b>Dr. Penina Axelrad, Professor and Chair, Department of Aerospace Engineering Sciences, University of Colorado, Boulder</b>
<b>Member-at-Large</b>	<b>Mr. N. Wayne Hale, NASA (Ret.), Consultant, Special Aerospace Services</b>
<b>Member at Large</b>	<b>Dr. Elisabeth Paté-Cornell, Professor and Founding Chair, Department of Management Science and Engineering, Stanford University</b>
<b>Member at Large</b>	<b>Mr. Miles O'Brien, Independent Journalist</b>

**Ex Officio Members**

**Dr. Alan H. Epstein**, *Chair, Aeronautics and Space Engineering Board, National Academy of Engineering*

**Dr. Fiona A. Harrison**, *Chair, Space Studies Board, National Academy of Sciences*

## APPENDIX C

### MEETING ATTENDEES

#### ***NASA Advisory Council Members:***

General Lester L. Lyles, *Chair*

Dr. Wanda Austin

Dr. Penina Axelrad

Mr. Kenneth Bowersox

Dr. William Ballhaus

Ms. Marion C. Blakey

Dr. Alan H. Epstein, *Ex Officio*

Mr. N. Wayne Hale

Dr. Fiona A. Harrison, *Ex Officio*

Mr. Miles O'Brien

Dr. Elisabeth Paté-Cornell

Dr. Bradley Peterson

Ms. Kathryn Schmoll

Ms. P. Diane Rausch, *Executive Director*

Dr. Patricia Sanders, *ASAP Chair*

#### ***NASA Attendees:***

Barry, Bill

Belson, DaMara

Broadwell, Marguerite

Cheek, Diane

Conley, Catharine

Cremins, Thomas

Dale, Shana

Denning, Elaine

Free, Jim

Gerstenmaier, William

Girten, Beverly

Green, Mike

Hamilton, Carol

Hunter, Andrew

Irvine, Lynn

Jacobs, Robert

Jurczyk, Steve

Kaminski, Amy

Kincaid, Mike

King, Marla

Lightfoot, Robert

McKay, Meredith

Mullins, Todd

Roe, Lesa

Rodriguez, Irma

Schierholz, Stephanie

Siegel, Bette

Steele, Cindy

Ulrich, Burt

Wang, Jen Rae

U.S. Air Force (Ret.)

The Aerospace Corporation (Ret.)

University of Colorado, Boulder

U.S. Navy (Ret.)

The Aerospace Corporation (Ret.)

Rolls Royce North America

Chair, Aeronautics and Space Engineering Board,

National Academy of Engineering

Special Aerospace Services, NASA (Ret.)

Chair, Space Studies Board, National Academy of Sciences

Independent Journalist

Stanford University

Ohio State University (Ret.)

University Corporation for Atmospheric Research (Ret.)

NASA Headquarters

NASA Aerospace Safety Advisory Panel (ASAP)

NASA Headquarters

NASA Headquarters

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*NASA Advisory Council Meeting, March 30-31, 2017*

Wang, Jen Rae  
Weigel, Elsie  
Williams, Greg

***Other Attendees:***

Beckman, Bill  
Bincham, Jeff  
Coleman, Sandy  
Cowing, Keith  
Floyd, Mary  
Foley, Kevin  
Krishnamurthi, Anita  
Moloney, Michael  
Mulqueen, Mark  
Murphy, Brian  
Stofan, James  
Terrell, Kim  
Dittmar, Mary Lynne  
Zimmermann, Joan

***Telecon (Dial-In) Attendees:***

Angela Clark Williams  
Ana Wilson  
Anne Zulkolsky  
Bill Putter  
Chris Gilbert  
David King  
Diane Detroy  
Earl Hahn  
Garry Burdick  
Gale Allen  
Marcia Smith  
Mary Sladek  
Neil Patel  
Robert Zimmermann  
Steve Vetter  
Theodore Kronmiller  
William Barksdale  
Al Condes  
Alisha Brown  
Allen Li  
Bill Putter  
Bob Daley  
Brian Muirhead  
Cathleen Boggs  
Chris Cloutier  
Chris Delbert  
Chris Flaherty  
Daniel Schroy  
David Eisenman  
Gerald Han  
Garry Burdick  
Gib Kirkham  
Grace Chu  
Harold White  
Jason Crusan

NASA Headquarters  
NASA Headquarters  
NASA Headquarters

Boeing  
Focused Solutions, LLC  
Orbital ATK  
NASAWatch.com  
Ingenicomm, Inc.  
Boeing  
NAC Ad Hoc Task Force on STEM Education  
National Academies  
Boeing  
McAllister and Quinn  
NAC Ad Hoc Task Force on STEM Education  
Katz International Management  
Coalition for Deep Space Exploration  
Ingenicomm, Inc.

Ingenicomm, Inc.  
Zantech, Inc.  
Lockheed Martin  
NASA Headquarters  
VE Consulting  
Orbital ATK  
NASA Headquarters  
Aerospace  
NASA Jet Propulsion Laboratory  
NASA Headquarters  
SpacePolicyOnline.com  
NASA Headquarters  
Andres.com  
Symbiotek Systems  
Cisco

Boeing  
NASA Headquarters  
U.S. Senate Commerce Committee  
Health Science  
NASA Headquarters  
Boeing  
NASA Jet Propulsion Laboratory  
NASA Headquarters  
Lockheed Martin  
Consultant  
NASA Headquarters  
Office of Management and Budget  
NASA Jet Propulsion Laboratory  
Bigelow Aerospace  
NASA Jet Propulsion Laboratory  
NASA Headquarters  
Office of Management and Budget  
NASA Headquarters  
NASA Headquarters

Jason Davis  
Jeff Foust  
Jennifer Troxell  
Jerry Posey  
Jim Jacobs  
Jose Ramos  
Juan Casiah  
Karen Feldstein  
Kent Cress  
Kurt Hack  
Marguerite Broadwell  
Marc Boucher  
Melissa McGuire  
Michael New  
Michael Neely  
Micheline Tabiche  
Michelle Rodrigues  
Nick Cummings  
Philip Sloss  
Richard Manella  
Rick Irving  
Robin Gatens  
Shannon Stirone  
Simon Collins  
Steve Dennison  
Steve Merritt  
Steve Thompson  
Steve Clark  
Steven Ramm  
Tom Risen  
Tony Reichhardt  
Van Gillen  
Van Vereano  
William Barksdale  
William Pratt

The Planetary Society  
Space News  
NASA Headquarters  
Lockheed Martin  
OA  
U.S. Government Accountability Office  
Boeing  
NASA Headquarters  
NASA Headquarters  
NASA Glenn Research Center  
NASA Headquarters  
SpaceRef  
NASA Glenn Research Center  
NASA Headquarters  
Persing  
European Space Agency  
SRI International  
U.S. Senate  
Spaceflight.com  
NASA Headquarters  
NASA Headquarters  
NASA Headquarters  
Salien  
NASA Jet Propulsion Laboratory  
NASA Headquarters  
Afagee  
Millennium Space Systems  
Spaceflight Now  
Lockheed Martin Next Step  
Aerospace America  
Air and Space Magazine  
U.S. Senate Commerce Committee  
Business News  
Boeing  
Lockheed Martin



**APPENDIX D**

**NASA ADVISORY COUNCIL  
NASA Headquarters  
Washington, DC  
March 30-31, 2017**

**LIST OF PRESENTATION MATERIAL**

- 1) President's FY 2018 Proposed Budget for NASA - Andrew Hunter
- 2) Human Exploration and Operations Update - William Gerstenmaier
- 3) Human Exploration and Operations Committee Report - Kenneth Bowersox
- 4) Science Committee Report - Bradley Peterson
- 5) Aeronautics Committee Report - Marion Blakey
- 6) Institutional Committee Report - Kathryn Schmoll
- 7) NASA Special Presentation: "Hidden Figures/Modern Figures" - Robert Jacobs
- 8) Technology, Innovation and Engineering Committee Report - William Bauhaus
- 9) Ad Hoc Task Force on STEM Education Report - Anita Krishnamurthi